Developing wireless ECG device using Bluetooth protocol for interfacing with Android based applications

A thesis submitted in partial fulfilment

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in

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By

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based on research carried out
under the supervision of

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Supervisors' Certificate

This is to certify that the work presented in the dissertation entitled: "*Developing wireless ECG device using Bluetooth protocol for interfacing with android based applications"* submitted by Bablu Tiwari, Roll Number 215BM1004, is a record of original research carried out by him under our supervision and guidance in partial fulfilment of the requirements of the degree of *M.Tech Biomedical Engineering* in *Department of Biotechnology and Medical Engineering*. Neither this dissertation nor any part of it has been submitted earlier for any degree or diploma to any institute or university in India or abroad.

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Abstract

The current project involves the development of a wireless ECG recorder and an android application that can be integrated smoothly for use by health-conscious people or cardiac patients and clinicians as well for self-monitoring and feedback respectively. Briefly, the hardware as well as software for a wireless ECG device were designed and developed that was integrated with Android based application to display and records the user's ECG signal. The hardware incorporated microcontroller, MSP-430 that detected the cardiac signal and performed analog to digital conversion (ADC), digital filtering, QRS complex extraction and heart rate calculation using specific algorithms. During validation, the prototype successfully recorded the cardiac electric signals originated by subject's heart with distinct QRS complex and T peaks. However, a distinct P wave was lacking. Further, the signal was rectified and the background noise was amplified followed by amplifying the signal to a tractable level. Next, the signal was communicated to an android device using Bluetooth protocol by HC-05 Bluetooth module. The signal was successfully displayed graphically, and the data was stored after being digitalized for future referencing and processing using advanced algorithms. The developed prototype is a robust, accurate and low-cost ECG recorder with wireless signal transmission to android device. The hardware incorporates distinct filter and amplification system to eliminate artifact from active movement. The use of adaptive filter is proposed for possible future improvement, with the main goal being to build the amplification and filter system which communicates with an Android smartphone application.

Keywords: *Android application; ECG; Technical Expertise; Bluetooth Module.*

Chapter 1
Introduction

According to the increase in need for easy access to health care, innovation of latest and cost effective products are discoverable. This is a challenging for young scientist and engineers to produce the advanced technology that is not only easy to access, therefore also as valuable as the conventional equipment. The technical, user-friendly in the whole world is affording to use modern information and communication technologies for telemetry and telemedicine facilities informing the patients, as well as for originating cost-effective medical equipment right to personal application and easy to carry it**.**

Now a day the most widely used in healthcare sector Electrocardiogram (ECG) which is an important part of the latest health care. The patients which are suffering from heart related diseases, i.e. heart attack. The patient requires a frequent observation of ECG activities. Human body acts as a conductor. An ECG (Electro cardio gram) is a recording of the electrical activities of the heart. The different views of the heart can be estimated with various electrodes. ECG is in the form of a transthoracic decipherment of the electrical activity of the heart over a time and is recorded by electrodes covered with the skin of surface. The real-time data is recorded and displayed by the android phone external to the body, which contains about the heart's conductions system in the form of electrical impulses originated due to the polarization & depolarization of the sinoatrial node (SA) and atrioventricular node (AV) tissues.

My project is based on e-health system which explains an innovative concept for providing medical information and access to anyone/somewhere/anytime. On other concepts mobile health systems depend on Android phones and other mobile phones that can be also equipped with attractive health sensors.

To aim of a possible solution to the above project, this project is designed as a product based initiative, goals as wireless procurement of ECG and makes the data available for analysis on various platforms. Therefore, the Bluetooth is the antidote open source wireless technology which has been used in this project to increase the connectivity with various devices. The Arduino UNO is a low-cost and easily available microcontroller which is used for interfacing the analog circuit and Bluetooth module (HC-05). This eliminates the requirement of DAQs (data acquisition module). It is memorable that such devices will crustily cut the timing of obtaining medical

information and enable regular observation of patients even in remote areas. The proposed prototype accessible the compatibility of the device with others mole devices running on Android platform and with valuable windows.

1.1.1 Motivation and Objective of the thesis:

Due to increment in the life expectancy at birth, the higher income and levels of educations, populations aging and modern interconnected world, the rising demand for health and social services is one of the prevailing challenges for the research community across the globe. Initially, India is ranked 150th out of 193 countries, which is listed in the WBF (World Bank Forum), with an average life expectancy of 66.21 years.

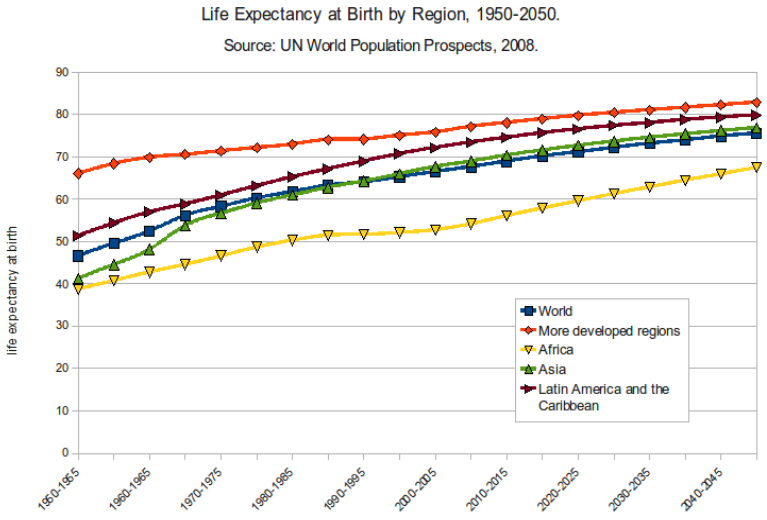


Figure 1 Life Expectancy at Birth by Region

ECG is one of the basic yet complex set of data about a person's health status. Diagnostic health analysis of a patient's ECG can indicate about as many as 60 diseases, symptoms, besides the heart rate blood pressure and status of the cardiac movement. The regularly observation and availability of ECG of a patient can help to maintain a healthy body.

To manufacture it available at a cost estimate and using the modern technology the probable alternative to conventional ECG acquisition device has to be originated over the exciting facilities like now a day wireless technology and hosting devices.

Hence the use of android devices and tablets with Bluetooth technology is one of the feasible application in healthcare.

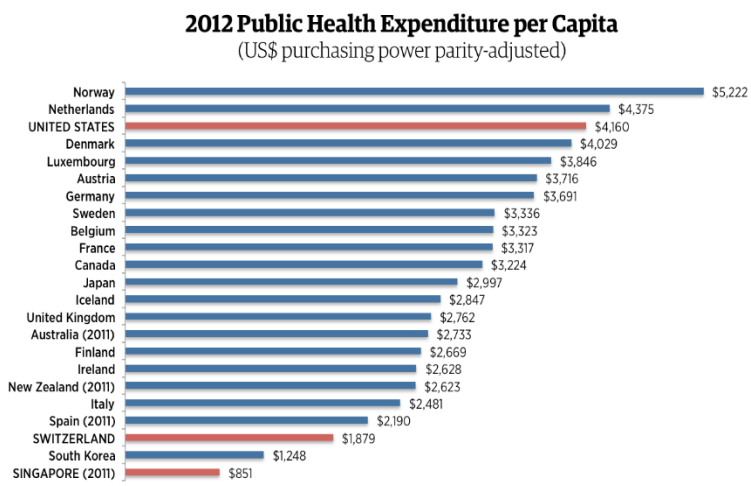


Figure 2 Public health expenditure per Capita

Chapter 2

Problem definition and objective

ECG signal is originated by the nerve impulse stimulation of the heart. The generated electrical pulses are thus diffused around the surface of the body and develops a voltage drop, which is a basically 0.0001 V to 0.0003 V and the produced signals are within the frequency range of 0.05 to 100 Hz.

The main prospective in the acquisition of ECG signal is disappearing noise and rectifying/amplifying the body signals so that you can get a correct ECG signal.

In the sense of wirelessly transmission of the signal, which has to be transformed into digital form and sent to a secure and intrusion free channel. ADC, which stands for analog to digital conversion works for proper verdict and transmission of data at proper rate is desired in order to eradicate any kind of distortion in the received data.

The originated unipolar signal from the level shifter circuit is given as input to the ADC of the Arduino UNO, which will be transmitted wirelessly via using Bluetooth. The major prospective here are: the rate of transmission, the conversion rate of the ADC. Which continue data integrity, the appropriate construction of digital bits to be transmitted, closeness of communication.

This category of the work comprises of getting back the signal in the actual form as it is original. The dissipation of the signal requires proper betterment of the data bits from the obtaining construction, accumulation of the bits in order to gain the signal waveform. This type of real time signal processing completed by MATLAB & Kubios HRV platform.

This is most valuable and important part of this project. The main objective of this project was to invention development of android platform and produce a prototype ECG application. Its architecture and progress platform and various tools which are used in the Android mobile application development.

2.1.1 How is ECG Measured?

The measurement of EKG(Electrocardiogram) based on the electrode system. Which can be associated into a number of pairs. The result data as a form of output is known as lead.
According to the number of leads the different types of ECG leads as are follows.

1) 3 lead
2) 5 lead
3) 12 lead

The different observation of the cardiac can be reported utilizing different electrodes.

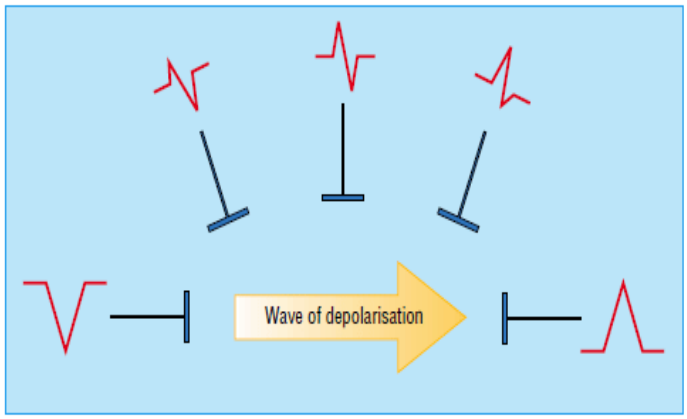


Figure 3 various views of heart

Basically, this a transthoracic rendering of the electrical activity of the cardiac overtime of time, as observation by electrode adjoin to the level of the skin and visualized by the appliance to the body. It contains the real time data regarding the heart conductions framework as electrical impulses originated by polarization & depolarization of cardiovascular tissue.

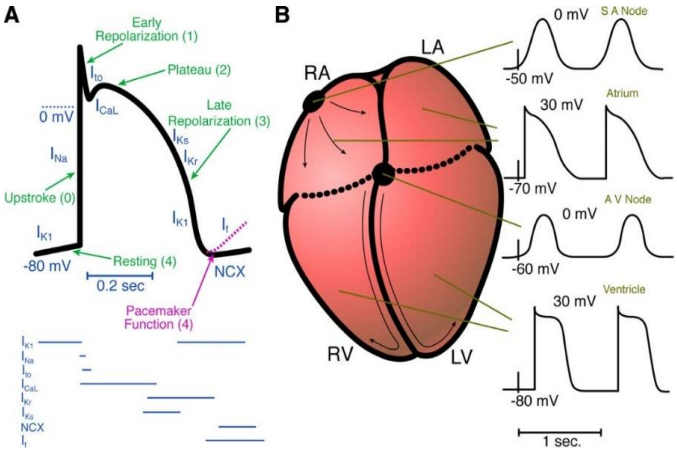


Figure 4 Voltage developed in the heart

The main objectives of thesis are:

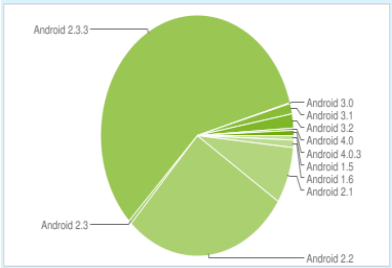
- ECG Signal acquisition from the body.
- Wireless transmission of the signal using Bluetooth.
- Dissipation and observation of signal from obtaining data in real time.
- The development of ECG Android Application using the Android Studio Platform

Chapter 3

Literature Review

This interdisciplinary area representing various applications in the area of wireless communication. A basic research interest in development of short range wireless technologies. Which including RFID identification, ZigBee & GSM, VLC and Bluetooth communication based system. Radio frequency application is especially amusing for applications requiring low power consumption, which may use even passive RFID transmission. The ZigBee is a low power, low data-rate automation, which granting the disintegration of a wireless ad-hoc mesh networks. But main demerits in implementation of handheld device like that cell phones, tablet MacBook and laptops. Solid state light devices were achieving in VLC based wireless technologies. The application of LED which can evaluate not only a global solution for brilliance, but also provide the extraordinary function of the low range wireless communication.

The open source wireless technology, which is valuable for use in e-Health systems are known as Bluetooth technology due to high inter connectivity between sensor and medical equipment like that Android phones, laptop and tablets.



Platform	Codename	API Level	Distribution
Android 1.5	Cupcake	3	0.6%
Android 1.6	Donut	4	1.0%
Android 2.1	Eclair	7	7.6%
Android 2.2	Froyo	8	27.8%
Android 2.3 - Android 2.3.2	Gingerbread	9	0.5%
Android 2.3.3 - Android 2.3.7		10	58.1%
Android 3.0	Honeycomb	11	0.1%
Android 3.1		12	1.4%
Android 3.2		13	1.9%
Android 4.0 - Android 4.0.2	Ice Cream Sandwich	14	0.3%
Android 4.0.3		15	0.7%

Figure 5 Android Studio Tools

3.1.1 Development of Android application using Android Studio platform

This process is performing an important role for implementing Android application. The various tools are required for the development of Android application.

3.1.1.1 Android:

A Linux based operating system that is targeted for mobile, smart phone & various types of tablet is known as Android operating system. Its openness & explicit features that access developers to gain full valuable benefits of features of the hardware devices.

The Android SDK is providing tools & different APIS that are used for developing mobile apps. It offers simple & powerful SDK that can be used for development in multi-platform. The possibilities are having via using various operating system like that Linux, Windows, Mac OS. The release of various updates & software function was accompanied by Android's mobile platform.

The Android 4.x (Ice-cream Sandwich) which was announced on October-2011 and updated on January-2012 to Android 4.0.3, Revision 2 (Ice-cream sandwich_MR1).

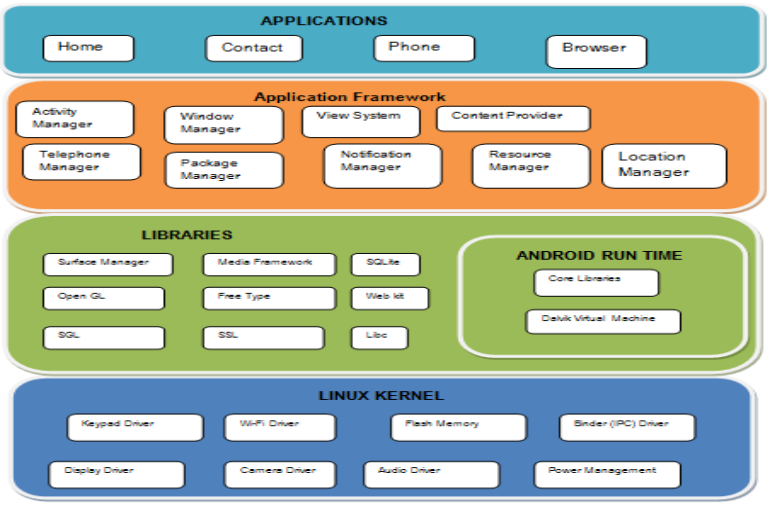


Figure 6 Android Architecture

3.1.1.2 Development & task goals

- This main objective of this project to manufacture & implement a prototype ECG application for the android platform.
- The vital sense ECG device (VS 100) are development, deployment & primary test purpose via using Lenovo a2010 device.
- The Java programming language, Eclipse & Android software development kit (SDK) are used as the tools of development & environment.
- The eclipse Android development tools (ADT) plug-in for a direct invoking of tools that are used for development of applications. The main goal of Visual paradigm UML (Unified modeling language) is used to draw cases & activity diagrams.

3.1.1.3 Research Activity

The documents of Android SDK and the vital sense ECG device manually are invaluable resources in the development work. Quantitative data & development work which will be acquired from the VS100 device is used in the analysis.

3.1.1.4 The Android Platform and Vitalsence ECG Device

According Days. According to the result, various varieties of handsets and handheld tablets running android operating system. Which are distributed by different mobile carries & manufacturers that share the majority of the global market. A fault-tolerant process is performed by android operating system for secured & efficient design. The Core applications like browser, contact & phone, an Application Framework that enables in replacement & reuse components; various libraries for multimedia, database. A Linux kernel that is responsible for memory management & security issues. There are the main components of the Android operating system (OS) as are follows.

3.1.1.5 The Linux Kernel

The responsibility of services like memory & process management, security, network stack, threading, camera, and audio drivers are performed by this part of the layer. Generally, we use Linux 2.6 version for handling the mentioned process in above architecture.

3.1.1.6 Android Runtime

This layer includes the Dalvik Virtual Machine (DVM) & a set of core libraries which handles different functionalities found in core Java libraries. The Dalvik Virtual machine (DVM) is a register based architecture that is manufactured for systems discretion in terms of memory & processor speed.**4.2.3 Libraries.**

Android platform contains a set of C/C^{++} libraries that are responsible for performance for functional & efficiency which includes.

a) System C library that is a modification of the standard C system library tuned for embedded Linux-based devices (Android developers).

b) Something media libraries that help playback and recording of popular video and audio formats.

c) SQLite that is a lightweight relational database engine.

d) LibWebCore, a latest web browser engine.

e) SGL a 2D graphics engine, 3D libraries based on openGL ES 1.0 APIs, Surface manager & extra.

3.1.1.7 Application framework

There are specified some of the components of the application framework layer which are followed

a) Content providers-which manages access to a central stored data.

b) A resource manager which provides activate to resources like graphics, layout & more.

c) For displaying custom alerts by using a notification manager.

d) For handling the applications of life cycle by using an activity manager.

3.1.2 What is ECG?

The heart generates an electrochemical impulse that spreads out in the heart in such a fashion as to cause the cells to contract and relax in a timely order and, thus, give the heart a pumping characteristic. This sequence is initiated by a group of nerve cells called the Sinoatrial (SA) node, resulting in a polarization and depolarization of the cells of the heart. Because this action is electrical in nature and the body is conductive with its fluid content, this electrochemical action can be measured at the surface of the body. An actual voltage potential of approximately 1 mV develops between various body points. This can be measured by placing electrode contacts on the body. In this application, the subject's limbs act as the differential point of contact with conductive pads to detect the ECG signal. Human heart contains different valves like that bicuspid valve & tricuspid valve. It's having sinoatrial node (SA node) & atrial ventricular node (AV node).

3.1.2.1 Background

The heart is situated obliquely between the lungs in the mediastinum. All about two-thirds of its bulk lie to the left side of the midline of the body. It is shaped like a blunt cone. It is about the size of a closed fist. It is approximately 5 inches long (12 cm), 3.5 inches wide at its broadest point (9 cm), and 2.5 inches thick (6 cm). It is enclosed in a loose fitting serous membrane known as the pericardial (pair –in-CAR-dee-al) sac, which have referred to as the parietal pericardium. The pericardial sac is made up of two layers. The outermost layer is the fibrous layer or fibrous pericardium (**FYE**-bruss **pair**-in-**CAR**-dee-um). It is made of tough, fibrous connective tissue and connects to the large blood vessels that enter and leave the heart (the venae cavae, aorta, pulmonary arteries, and veins), to the diaphragm muscle, and to the inside of the Sternal wall of the thorax. It prevents over distention of the pumping heart by acting as a tough protective membrane surrounding the heart. It also anchors the heart in the mediastinum. The innermost layer of the pericardial sac is the serous layer or serous pericardium.

3.1.2.2 The Anatomy of the Heart

The basic concept of a human heart is based on galvanometer principle. Due to the firing of sinoatrial node (SA node), the automatically sodium gated channels are (Na^+ channels) open. After the opening of sodium channels, the Na+ ions enter from the sinoatrial node. These ions are participating in producing electricity from the SA node. The depolarization of Na^+ ions occurs after the firing of the SA node. The depolarization of Na^+ ions to take participate the generation of minor electric current from sinoatrial node. The current is originated from the SA node & passes through myocardial tissues. An origination of depolarization current after incoming of potassium ions (K^+ ions) & outgoing of calcium ions (Ca^{++} ions) from myocardial cells. When the myocardial cells completely depolarized then atria-ventricular (AV node) will be fired. A small current will be produced due to firing of the AV-node. The galvanometer needle fluctuation occurs after the depolarization process. In representation of chart graph paper the P-wave (P-peak) printed to record electrical activity. When the K^+ ions come into myocardial tissue & Ca^{++} ions passes from gated channels then QRS waveform originated. This is related to Parkinge fiber of the heart wall. After the polarization of whole myocardial cells means relies K^+ & Ca^{++} ions the repolarization process occurs. The generation of QRS complex (QRS-peaks) undergoes after depolarization process.

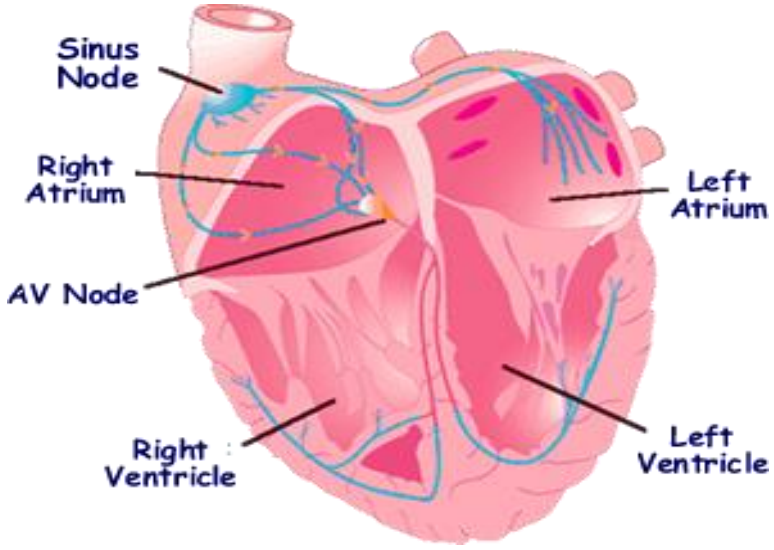


Figure 7 Heart anatomy & node description

3.1.2.3 Concept of Electrocardiogram

3.1.2.3 EKG/ECG

An electrocardiogram (EKG) is an analyzer that analyzes for trouble with the electrical activity (depolarization, repolarization of SA-nodes) of the dynamic organ (heart). An ECG represents the heart's electrical activity as line tracing on the chart paper, & the fasten dip in the tracings is called waves.

The electrical systems due to the heart muscle to contract. The function of the heart to pump blood through the blood vessels to the lungs and the rest of the body vessel. The Electrocardiogram is the useful tool for postulating information about the function of the heart. ECG is valuable for the detection of cardiac irregularity.

A brawny R and QRS peaks determination using Wavelet Transform have been examined. This transform provides energetic localization in both time and frequency.

Discrete Wavelet Transform (DWT) has been applied elicit relevant information from the EKG signal classification. EKG signal italicizes parameters are for signal analysis, diagnosis, authentication and identification performance. HRV analysis is used to send information about the autonomic heart rate mechanism for this a pre-processing of the RR interval time series is a necessity.

The EKG is delineated by a recurrent wave sequence of P, QRS, and T-wave which associated with each beat. The approximately QRS complex is the peak striking waveform, due to originating by ventricular depolarization (SA-node) and atrial repolarization process.

Figure 8 a visual guide to heart attack

3.1.2.4 How is ECG measured

The posture of the QRS complexes is observed by using a Pan Tompkins algorithm, the position of other exponents of EKG like P, T waves and ST segments is observed relative to the position of QRS waveform, in order to complete cardiac time interval. Electrocardiograms (EKGs) are used healthcare professionals to monitor ECG waveforms of the heart of a patient.

These devices occasionally operate with up to 6-leads (V1 to V6) & 6-limb leads connected to the patient's skin in a defined pattern. An EKG can be applied to observe abnormal cardiovascular symptoms, measure heart rates, and monitor heart rate abnormalities. The most common application of an EKG is to measure a heart rate during a workout as well as jogging time; the aim of this project is to develop a prototype device that could aid remote monitoring and feedback system.

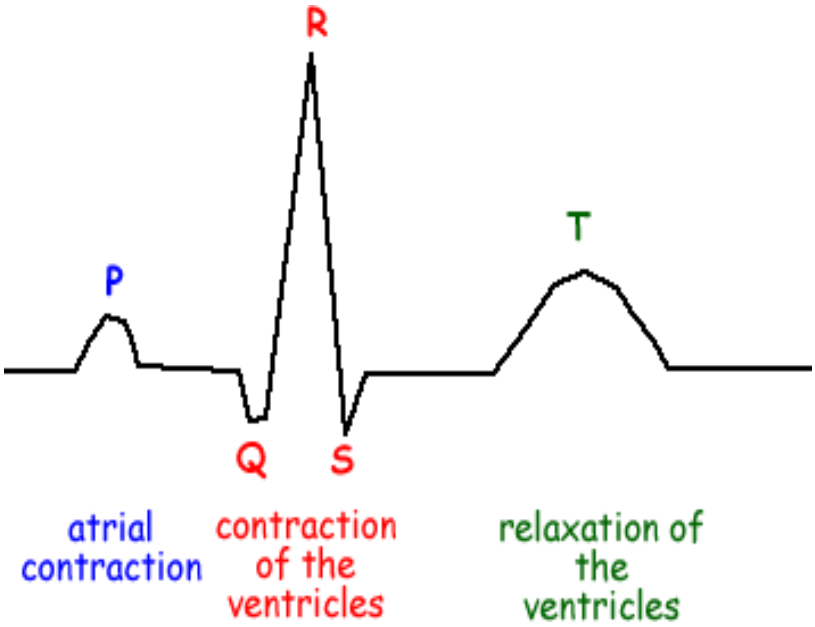


Figure 9, ECG ,P, Q,R,S,T, waveform

The Characteristics of the ECG Signals as are follows.

a) Basically the ECG comprises of low amplitude voltages in the vicinity of high amplitude offsets and noise.

b) The advancement offsets exhibit in the framework is due to half-cell potential created at the anodes.
c) Silver-Silver electrode is the regular cathode utilized as a part of ECG framework and has a greater balanced voltage of +/- 300 mV.
d) The real time craved signal is +/- 0.5 mV overlap on the anode balance.
e) This prototype extendible gets the 50 dB noise from the electrodes and electrical cables which makes the basic mode signal.

Chapter 4
Materials and Methodology

4.1.1 Work Plan

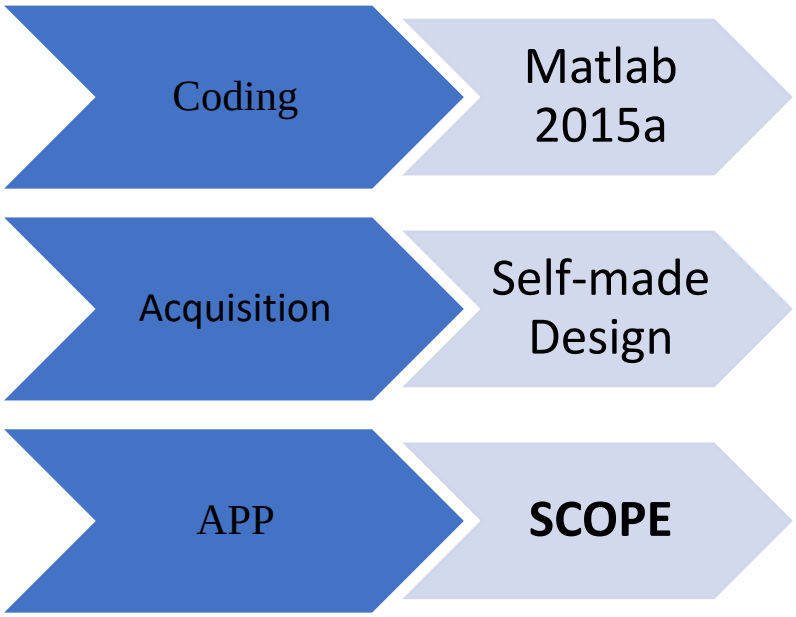


Figure 10 Work plan related to estimated project

4.1.2 Hardware Circuit

This is section related to backbone of this project. An important section which has played an important role for fabrication of ECG recording based circuit. The manufacturing of hardware kit a very basic electronic components are required. Which is easily available in the market and very easy to fabricate respective circuit. Under this section very valuable effort and cost effective components are sufficient for the fabrication of ECG circuit. In sense of very low power amplifier we are using low power consumption Instrumentation amplifier (INA128P). Then, after the amplified or very low power consumption, we have required the noise elimination which covered by the filtering process. The filter design technique has fulfilled by the help of operational amplifier (Op-amp741) and basic resister capacitor components. The filtered real time signals are required a DC-level shifter. Another processed signal has send to Analog to digital converter by passing through Arduino Uno. The analysis of the real time data we are using HC-05 Bluetooth module.

4.1.2.1 ECG Acquisition Circuit

The functional diagram of hardware architecture for the proposed model as are follows.

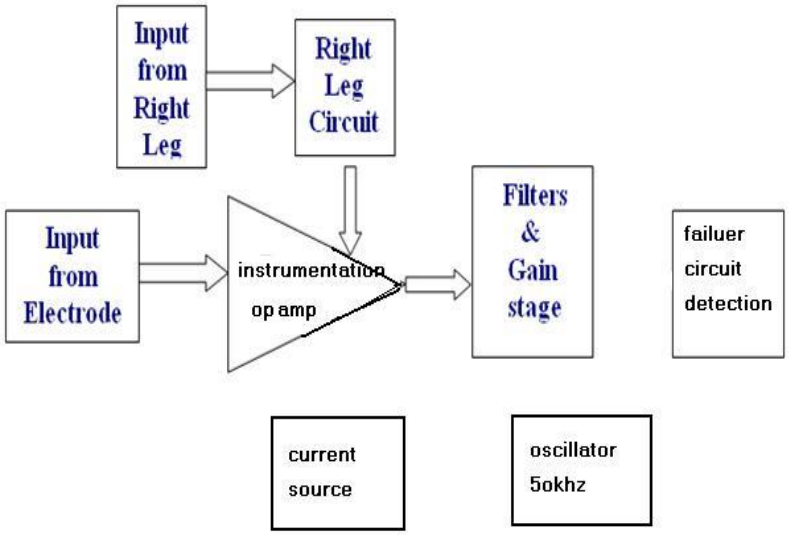


Figure 11 Block diagram of ECG Circuit

My work can be widely divided into three main parts. Initial stage, I was concerned regarding the ECG signal acquisition part. Therefore, I gave intensity on developing my own circuit rather than importing an inbuilt sensor.

It is already described that basically the ECG signal contains the frequency range of the order of 0.5 Hz to 200 Hz. So, in the sense of data acquisition circuit care must be taken to incorporate filters as well. In this circuitry for noise elimination, we require both low pass as well as a high pass filter.

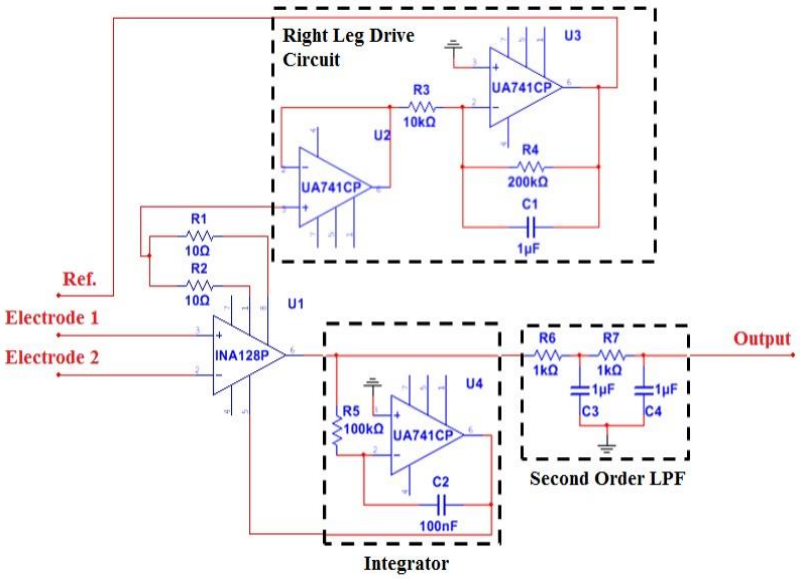


Figure 12 Estimated ECG circuit diagram

There are following hardware components are required in this project.

- Breadboard
- Arduino UNO
- Bluetooth Module (HC-05)
- Operational Amplifier (op-amp741)
- Instrumentation amplifier (INA128P)
- Resistors & Capacitors

- Ag-AgCl disposable electrodes
- Recording leads
- Electrode gel
- Function generator
- Cathode Ray Oscilloscope (CRO)
- PCB Board
- Android phone
- Connecting wires
- Battery (9V)

a) Breadboard

A breadboard is a construction base for prototyping of electronics. Originally it was literally a breadboard, a polished piece of wood used for slicing bread. In the 1970s the solderless breadboard (AKA plug board, a terminal array board) became available and nowadays the term "breadboard" is commonly used to refer to these.

Figure 13 Breadboard

b) Arduino Uno

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project is based on microcontroller board designs, manufactured by several vendors, using various microcontrollers.

Figure 14 Arduino Uno

c) Bluetooth Module/Wireless Communication

This part is playing a very important role in the project. Real time data transmission is completely dependent on the basis of this project. So, for communication, I am using Bluetooth technology. After acquiring the real time data of ECG, we can say that after filtering and amplification, this will be fed to first input to voltage shifter circuit for ADC channel of the Arduino Uno (Microcontroller) which is connected to the Bluetooth module HC-05. After this data will be sent and received back from the Bluetooth connected Android phone/Tablet.

Therefore, here we are handling with the following steps: First conversion of ECG bipolar signal (with the voltage swing in both the directions across zero) to a unipolar signal (only DC signal

after that use of Microcontroller for interfacing purpose, and also the serial communication through the Analog to digital converter (ADC) pin, after this process the transmission of real time data by using HC-05 Bluetooth module.

So, the transmission & receiving the data proper care must be taken of the synchronism as if this is lost, it will be very much difficult to get back the previous signal. Therefore, the proper baud rate must be set and it should be same for Receiving end as well as transmission end.

d) Bluetooth based technology

This technology is the major part of this project. We used the HC-05 Bluetooth serial module category. This will transmit the real time data whatever data it will receive from the connected Arduino Uno board through the serial communication process.

Basically the Bluetooth module has categorized in three families.

i) HC-04

It has two types of modules; HC-04M for master mode and HC-04S for slave mode.

ii) HC-05

It has both the modes i.e. Master and Slave modes. By default, it is in master mode. However, it needed the slave mode can be activated using AT command.

iii) HC-06

The functions only in slave mode. The pairing of this module can be done by a master device upon triggering the sequence. This device in 'AT' mode before the communication in which we can set different parameters like that name of the Bluetooth, Baud rate etc.

Following the slave and master mode describes a number of times. So, it is better to know their outcomes.

- Master Mode: In this mode the module has no function to memories the previous paired device. So, it can be made to pair with any of the slave devices.
- Slave Mode: Under this mode the module remembers the previous devices.

Figure 15 HC-05 Bluetooth Module

e) Operational Amplifier (Op-amp741)

The LM-741 is general purpose operational amplifiers which features improved performance of the various electronic components oriented industries. The main features of op-amp 741 for the protection on the input and output. There is not Latch-Up when the common mode range is exceeded. In this circuitry we are using 741 Operational Amplifier which is having ultralow offset voltage instrumentation OPAMPs. This helps to reduce the common mode gain. Thus, efficiency and accuracy are increased many times.

f) Instrumentation Amplifier (INA128P/INA101 HP)

Instead of traditional amplifiers we are using an INA128P Instrumentation amplifier. This is having very high common mode rejection ratio (CMRR) and high input impedance which is required for capturing/rectify ECG signals. The Analogue devices like that AD620/INA128/328EN which was chosen for implementation in the system. These are the INA101HP Instrumentation amplifier is a high accuracy instrumentation amplifier designed for low level signal amplification and general purpose data acquisition. Three

precision Op-amp and laser trimmed metal film resisters are integrated on a single monolithic integrated circuit (IC).

Figure 16 Instrumentation amplifier (INA128 HP)

g) Low pass and High pass filtering design

The low pass filter was fabricated cascaded RC, or passive filters. The signal was bad limited using a second order passive filter having a cutoff frequency of approximately 740 Hz. The band limitation of the signals was also achieved this way.

h) Mathematically Operations/ Calculations

1) The gain in the INA128/INA128EN can be obtained by using following equation

$$\text{Gain} = 1 + \frac{50\ k\Omega}{20\Omega}$$

Where R_G is resistance between pins 1 and 8.

$$\text{So gain} = 1 + \frac{50k\Omega}{20\ \Omega} = 2501,$$

Which approximately equal to gain of ~ 2500 times

The cut-off frequency of the low pass filter

2) Can be calculated by using formula

This is related to second order

$$F_C = \frac{1}{2*\pi*RC}$$

Which R= 470 Ω, C = 1 μF (1st Stage)

And R= 100 Ω, C = μF (2nd Stage)

When cascaded will have a cut-off frequency of about 742 Hz, which is large enough for the signal to pass.

3) Now to remove the DC- offset I have used an integrator

Now, for the integrator, the transfer function is given by:

$$\frac{V0(S)}{Vi\ (S)} = -\frac{1}{sRC}\ \text{Vi (S)}$$

$$=> V_0\,(S) = -\frac{1}{sRC}\ \text{Vi (s)}$$

Giving the values of R= 100 kΩ and

C= 50 nF

we get the cut-off frequency 15.8 Hz

4.1.2.2 Simulation of data acquisition model

Proteus (PROcessor for TExt Easy to USe) is a fully functional, procedural programming language created in 1998 by Simone Zanella. Proteus incorporates many functions derived from several other languages: C, BASIC, Assembly, Clipper/dBase; it is especially versatile in dealing with strings, having hundreds of dedicated functions; this makes it one of the richest languages for text manipulation. Proteus owes its name to a Greek god of the sea (Proteus), who took care of Neptune's crowd and gave responses; he was renowned for being able to transform himself, assuming different shapes. Transforming data from one form to another is the main usage of this language.

Proteus was initially created as a multiplatform (DOS, Windows, Unix) system utility, to manipulate text and binary files and to create CGI scripts. The language was later focused on Windows, by adding hundreds of specialized functions for: network and serial communication, database interrogation, system service creation, console applications, keyboard emulation, ISAPI scripting (for IIS). Most of these additional functions are only available in the Windows flavor of the interpreter, even though a Linux version is still available.

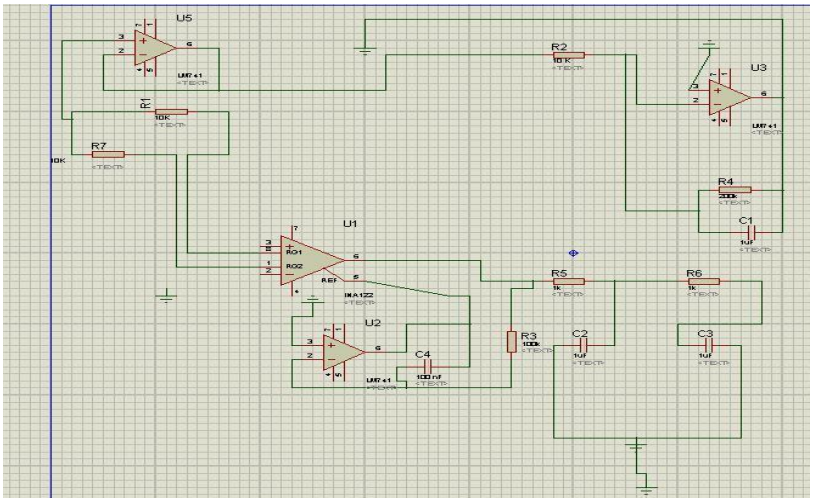


Figure 17 Estimated simulation circuit in Proteus 8

For testifying this circuit, I had provided a sample input to the lead 1 and lead 2 and grounded the reference, after the desired output was coming.

- Input Signal to reference lead: Grounded

- Input Signal to lead 1:

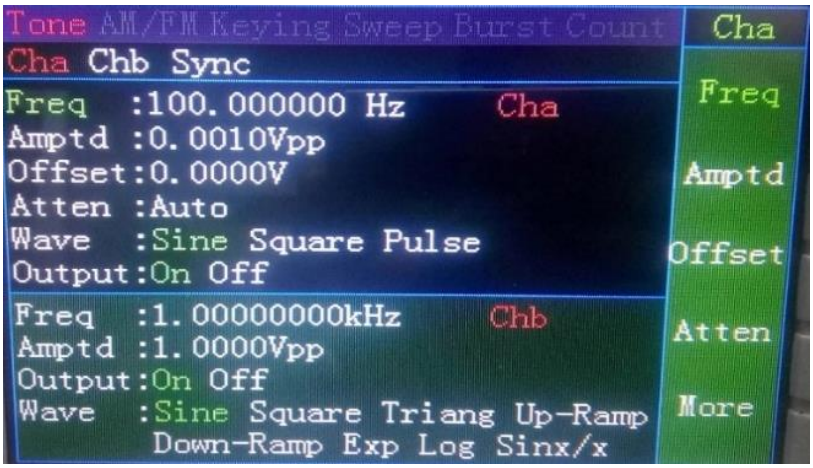


Figure 18 Input signal in lead 1 during test

4.1.2.3 PCB Circuit assembling

The ECG acquisition hardware circuit and the signal shift circuit were embedded into a single unit which can operate individually without the microcontroller. The circuit schematic is represented in following figure.

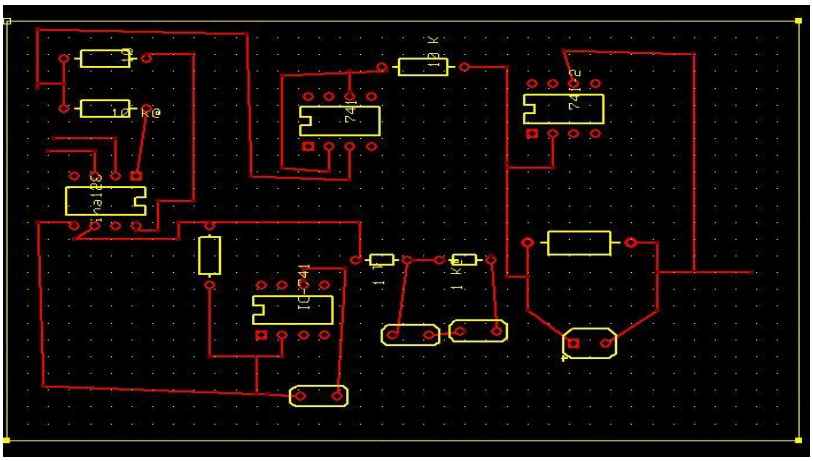


Figure 19 Schematic circuit layout in Eagle software

4.1.2.4 How is ECG Measured?

The measurement of EKG(Electrocardiogram) based on the electrode system. Which can be associated into a number of pairs. The result data as a form of output is known as lead.

According to the number of leads the different types of ECG leads as are follows.

a) 3 lead
b) 5 lead
c) 12 lead

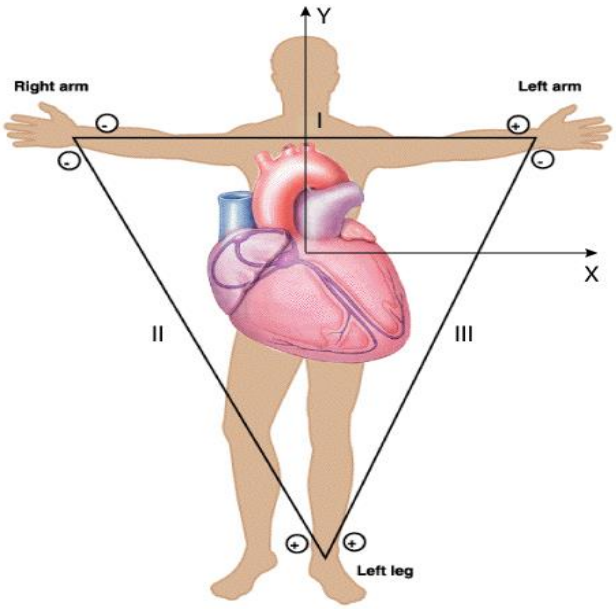


Figure 20 Positions for three leads connection

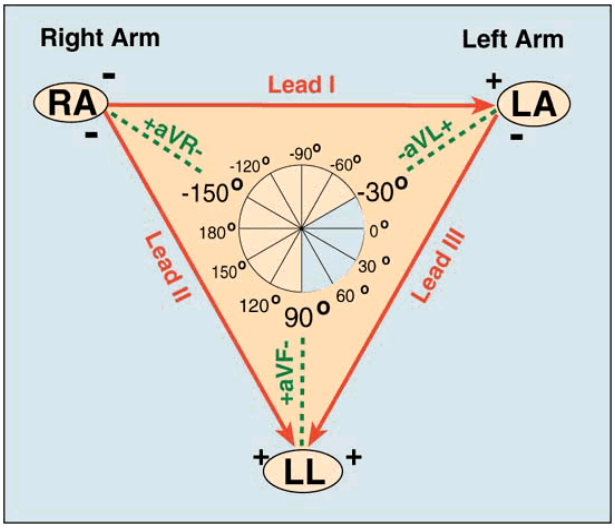


Figure 21 Lead-I wave

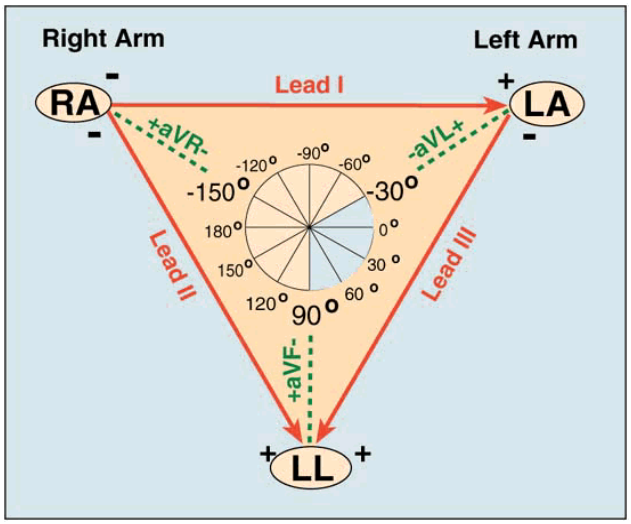


Figure 22 Lead II wave

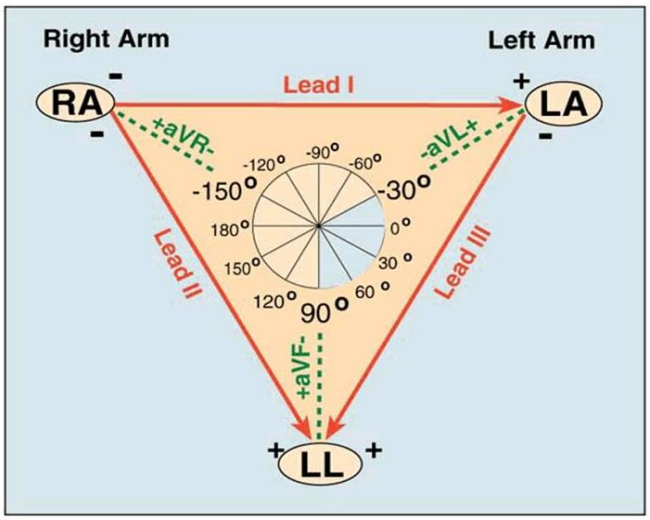


Figure 23 lead III wave

4.1.2.5 ECG Electrodes (Ag-AgCl)

Disposable ECG Electrode is Ag or AgCl electrode, which consist of base lining material, conductive gel, and electrode buckle. The base lining material uses the nonwoven fabric, the breathable paper, cotton or PE and foam with medical hypoallergenic adhesive.

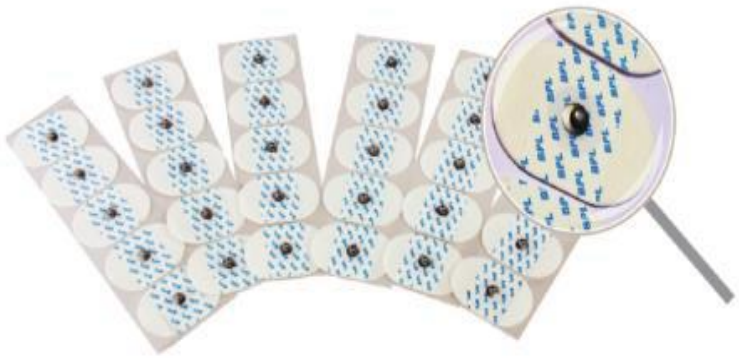


Figure 24 Ag-AgCl disposable ECG electrodes

4.1.3.1 Android application & development environment

Generally, an Android development platform in the Java language which compiled into byte codes that will be converted to a dalvik executable file via using dx converter. This will be compiled into apk file (Android package file) that can be installed on the android devices.

The four basic application components are composed by Android applications.

i) Activity

Activities performed a core task which can be operated by the application. A single screen user interface is represented by activity which interacts to do functions like dialing, taking photos. An android ECG app can have activity that shows the heart rate samples & other activities.

j) Services

The services are responsible for tasks like that updates & remote control processes. These types of services implementation just like time taking operations and processes that require to be scheduled and continuously regularly.

k) Content Providers

Content providers are using for the interfacing to data which helps to contain shared data for the applications. These data can be participate & rebuild according to permissions using the content providers.

l) Broadcast receivers

The announcement, which made by the system is known as broadcast receiver. Since the initiation of services which can do something via a performed broadcast receiver.

4.1.3.2 VS 100 (The Vitalsens)

This design performed in the measurement of different vital signs. The flexibility & shape of the device perform it comfortable to be worn & used by patients. This system can be used to calculate data like heart rate, skin surface temperature & body movement.

This type of Bluetooth based wireless technology is applying for the handling data transfer between the receiving device. The VS100 is made up of a body-worn unit with an ECG prototype, a thermistor for skin temperature & for detecting the body tri-axial motion is using gyro-accelerometer sensor.

This software accessible for the users to monitors Heart rate signals. This output device is represented to the real time Heart rate signals.

Figure 25 ECG and heart beat signals from a user on the Vitalsens software

4.1.3.3 Android app development

The following activity diagram shows simplified overall activities in the applications.

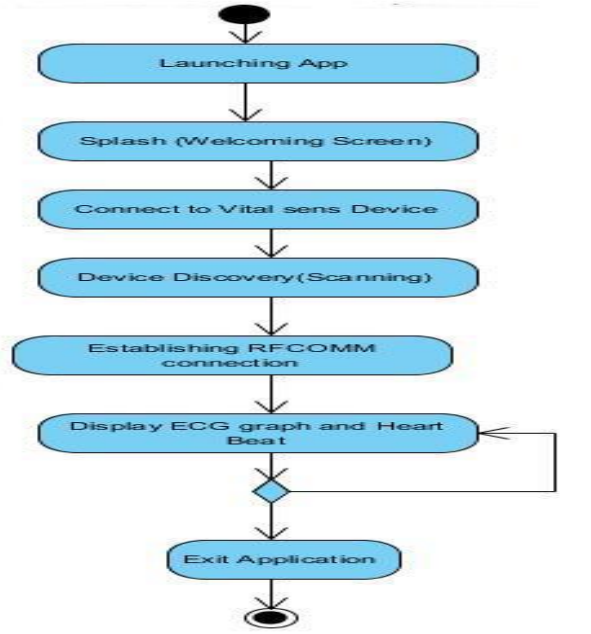


Figure 26 Activity diagram of the application

4.1.3.4 Implementing the Android ECG App

This section is defining the implementation of the Android ECG application. The various resources define that manufactured application is describing here.

The following is a code snap shot of the Android manifest file of the application.

<?xml version="1.0" encoding="utf8" ?><manifestxmlns:android="http://schemas.android.com/apk/res/android" package="com.woubshet.bluetoothhr" android:versionCode="1" android:versionName="1.0" ><uses-sdk android:minSdkVersion="10" /><uses-permission android:name= "android.permission.BLUETOOTH" /><uses-permission android:name="android.permission.BLUETOOTH_ADMIN" /><application android:icon="@drawable/ic_launcher" android:label="@string/app_name" > <activity android:label ="@string/app_name" android:name=".BluetoothHr" ><intent-filter > <action android:name="android.intent.action.MAIN" /> <category android:name="android.intent.category.LAUNCHER" /> </intent-filter> </activity> <activity android:name=".HeartMn" android:screenOrientation="portrait">

<intent-filter><category android:name="*android.intent.category.LAUNCHER*" />

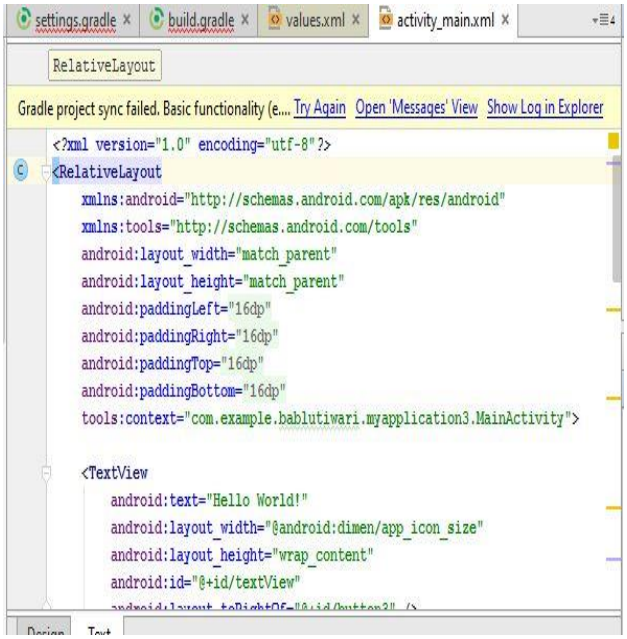


Figure 27 code snapshot from Android Studio

4.1.3.5 User Interface

This section describes the user interface implementation of the android mobile application. In android application development the View and View Group objects are used to build the user interface. A view object represents data structure whose properties store the layout parameters and content on a given specific area of the Screen.

The layout for different activities in an application can be defined using the XML based layout file.

The application is comprised of three activity classes and a service class. The first activity class that is implemented as the welcoming screen is represented by the main lay out view.

The main View is defined in the main.xml layout file of the resource of the application. The file resides in the “resources/layout” folder.

The following picture shows the main layout view that represents the starting point of the application.

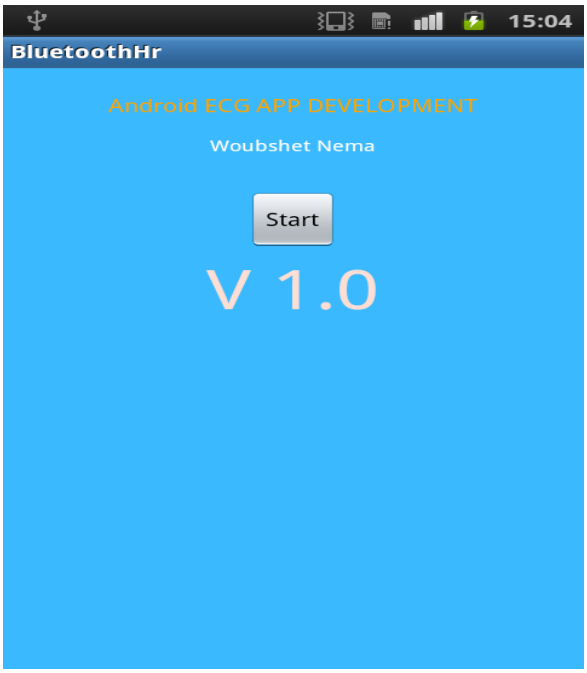


Figure 28 The main layout view of the application

The following is a code snippet of the XML file that is used in the main.xml of the main layout view.

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
android:layout_width="fill_parent"
android:layout_height="fill_parent"
android:orientation="vertical"
android:background="#3BB9FF"
>
<TextView
android:layout_width="wrap_content" android:layout_height="34dp"
android:layout_marginTop="20dp"
android:layout_gravity="center_horizontal"
android:text="@string/title"
android:textColor="#FFA500"/>
```

```
<TextView
android:layout_width="wrap_content"
android:layout_height="45dp"
android:layout_gravity="center_horizontal"
android:text="@string/author"
android:textColor="#ffffff" android:textSize="12dp"/>
<Button
android:id="@+id/start" android:layout_width="wrap_content"
android:layout_height="wrap_content"
        android:layout_gravity="center_horizontal"
```

After clicking the start button on the main layout view users will be directed to the next activity which is the HeartMn.java class that is represented with the Customs.xml layout view. Depending on the availability of Bluetooth on the user's device and whether or not bluetooth is turned on or off, the user will be directed to either of the following screens.

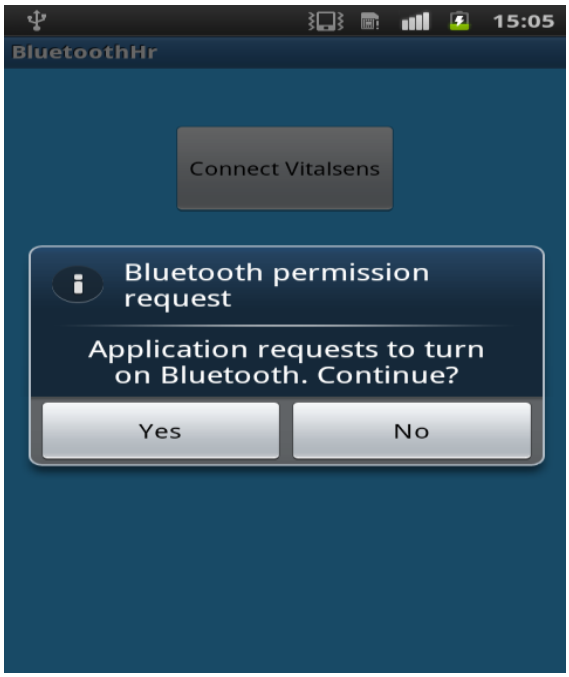


Figure29 Bluetooth customs.xml layout

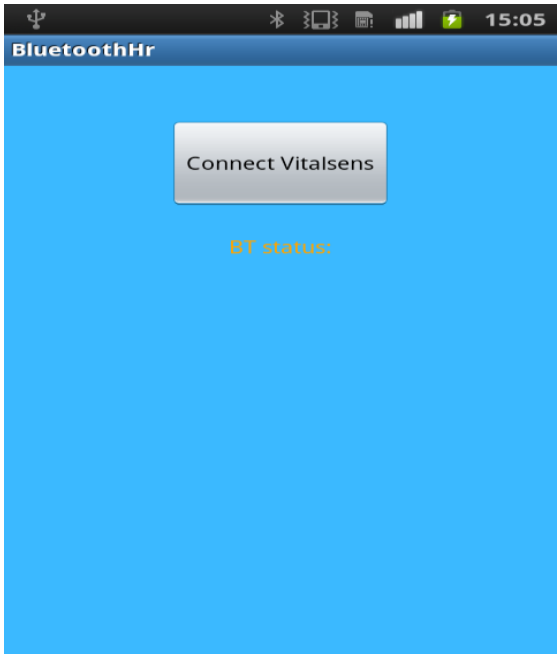


Figure 30 Developed Android app

4.1.3.6 Real time Signal Processing using MATLAB & Kubios HRV Software

Heart rate variability (HRV) is the physiological phenomenon of variation in the time interval between heartbeats. It is measured by the variation in the beat-to-beat interval.

The indices which are used are:

The R-R interval lists:

The RR interval variations present during resting conditions represent beat-by-beat variations in cardiac autonomic inputs.

The KUBIOS HRV software has:

1. 3 columns (T, RR, A)
2. 2 columns (RR, A)
3. 2 columns (T, RR)
4. 1 column (RR)

Where T is the time of occurrence of the beginning of the RR interval, RR is the duration of the RR interval, and A is a beat label. Normal sinus beats are labelled N.

LF and HF components: include both sympathetic and vagal influences

It is important to note that HRV measures fluctuations in autonomic inputs to the heart rather than the mean level of autonomic inputs. Thus, both withdrawal and saturating high levels of autonomic

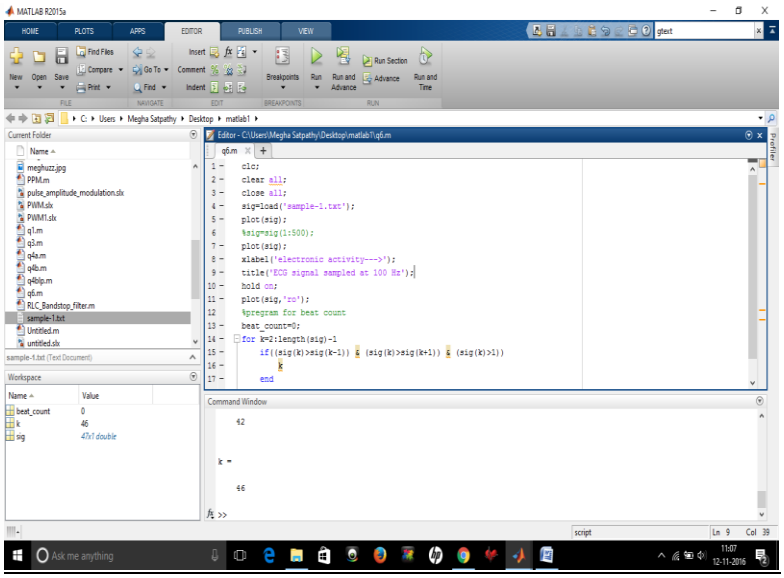


Figure 31 MATLAB Code for HRV analysis

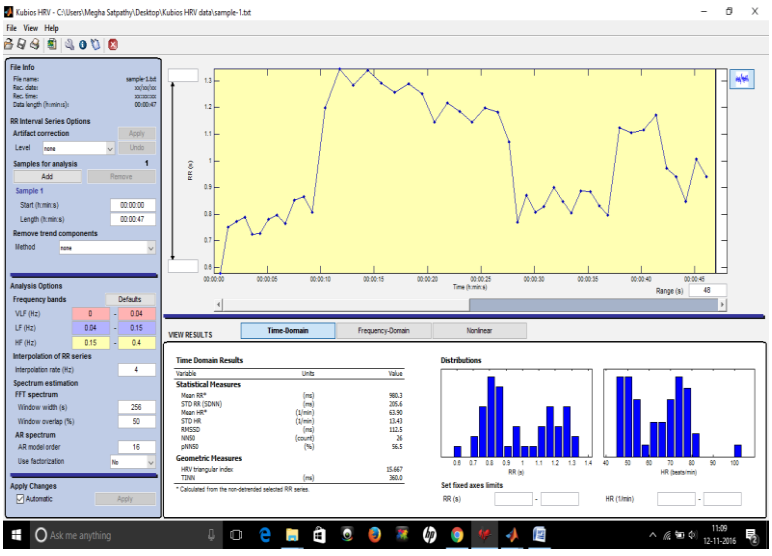


Figure 32 Define parameters using Kubios HRV Software

Chapter 5
Results and discussion

5.1.1 Circuit Simulation & developed PCB kit

After circuit simulation in Proteus 8.0 software. I had developed PCB circuit which are follows.

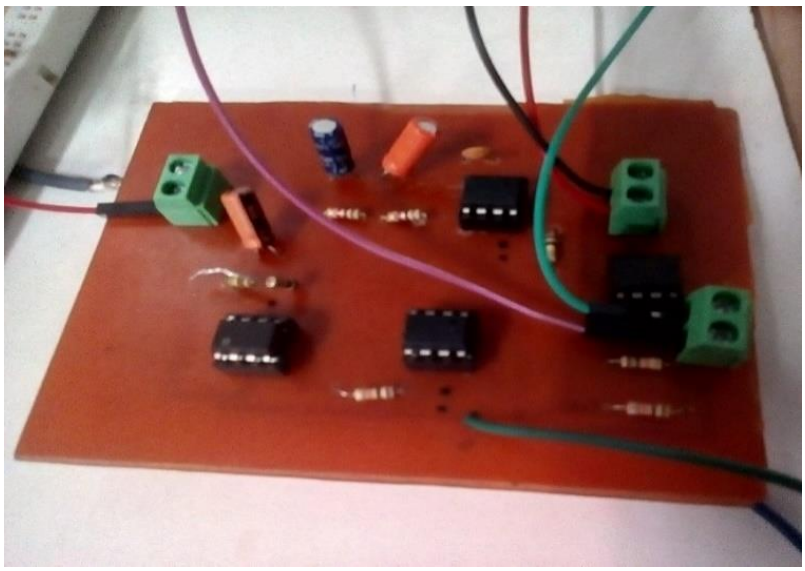


Figure 33 Final PCB designed of Schematic ECG Circuit

For testifying this circuit, I had provided a sample input to the lead 1 and lead 2 and grounded the reference, after the desired output was coming [1]

- Input Signal to reference lead: Grounded
- Input Signal to lead 1

5.1.1.1 Circuit validation through Function Generator and Oscilloscope

There are following Output waveform observation by using function generator and oscilloscope.

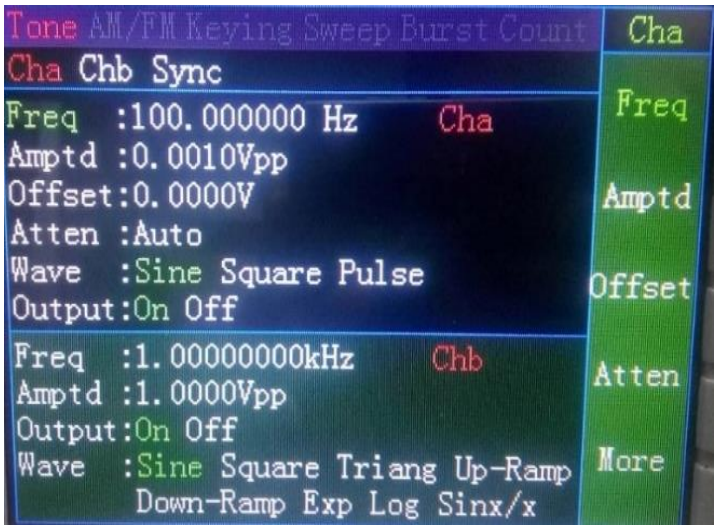


Figure 34 Input given by Function Generator

As, the slight mismatch was seen in the amplitude of input waveforms, the output waveform is basically sinusoidal.

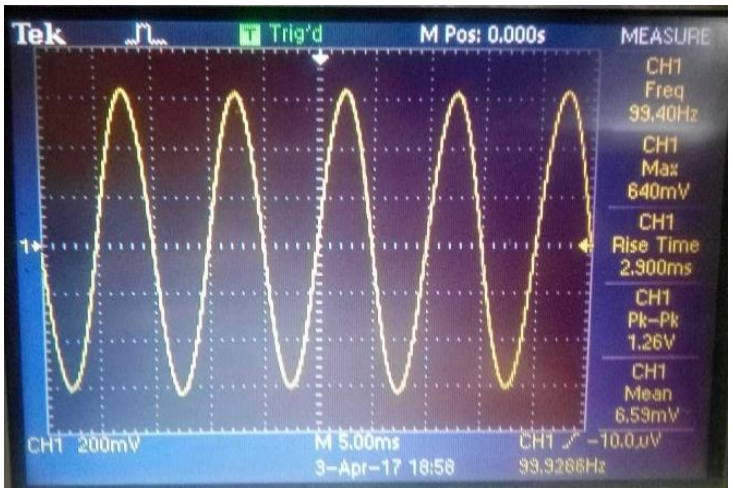


Figure 35 Sinusoidal output in CRO

5.1.1.2 Circuit Validation result using Function Generator & CRO

After the finalized implementation of circuit. We had observed the output results using function generator and oscilloscope. I had tested the results after perfect observation.

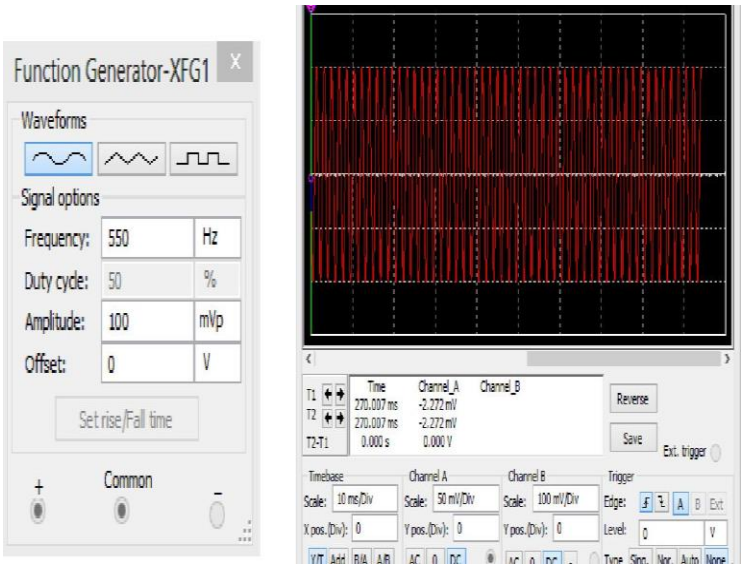


Figure 36 Results in Oscilloscope after Circuit validation

5.1.1.3 ECG Acquisition from the various Subject

The fabricated ECG circuit is used to record the signal directly from human body. The set up consists Ag-AgCl disposable electrodes & recording leads, which used with permission from the Medical Electronics Lab, Department of Biotechnology and Medical Engineering. The initially signal recorded with substantial noise as represented in the figure

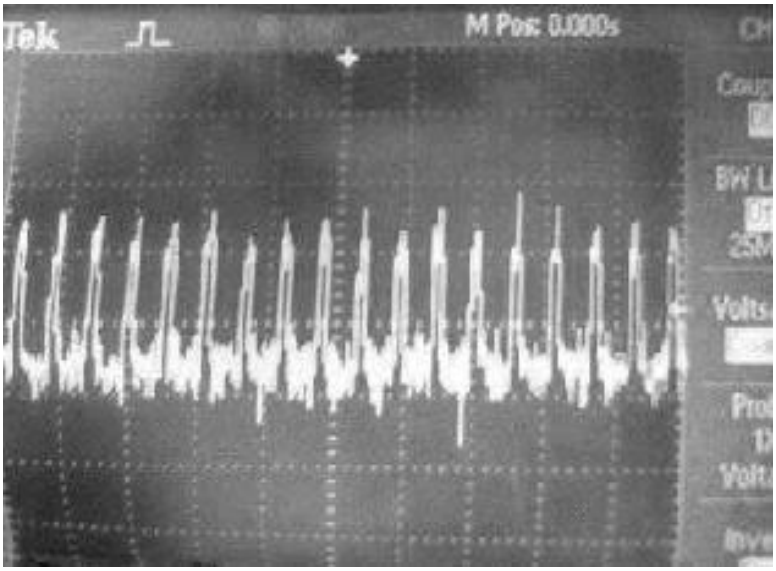


Figure 37 Real time ECG noise corrupted waveform in CRO

The recorded ECG real time data after noise elimination using adaptive filter analysis.

Figure 38 Real time ECG data after noise elimination

Real time ECG data recorded from the human beings displayed in oscilloscope.

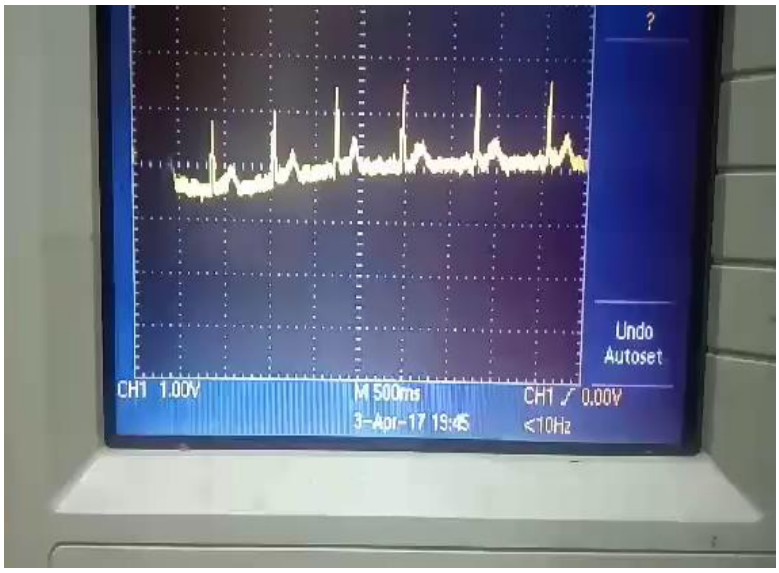


Figure 39 Real time recorded data in CRO

5.1.1.4 Developed Android ECG recording based application

There are following figures are representing the finally real time graph plotting based Android apps.

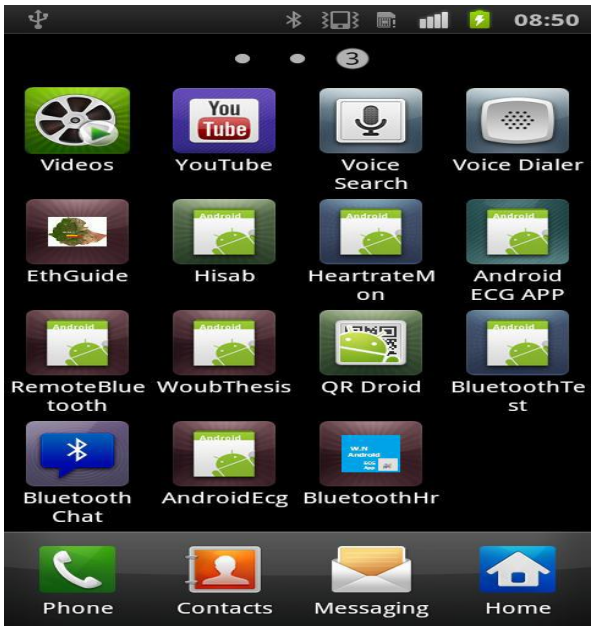


Figure 40 Developed Android App

Figure 41 Finally developed ECG based Android App

5.1.1.5 Algorithm developed by using MATLAB & Kubios HRV Software

There are following observation obtained by using Kubios HRV and MATLAB Software

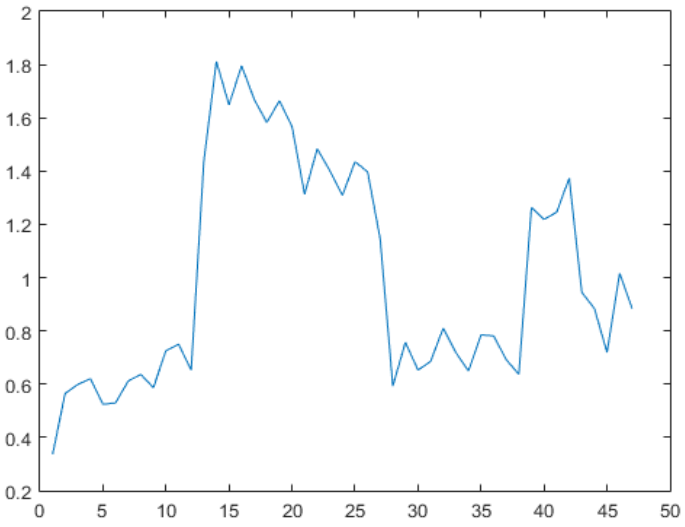


Figure 42 Observed ECG raw data in MATLAB

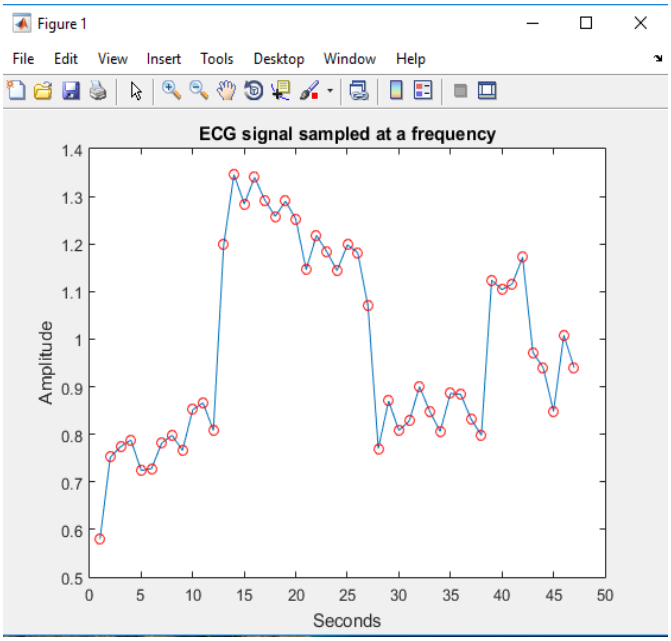


Figure 43 Observer QRS waveform from ECG raw data

Observation of dumped signal during the algorithm development

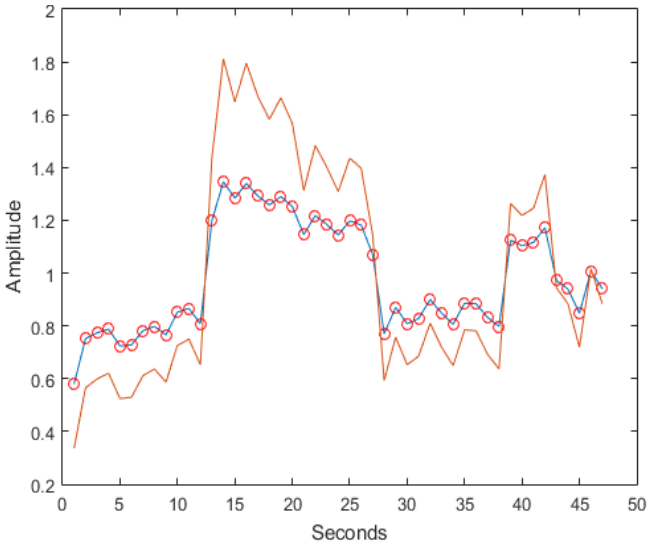


Figure 44 Observed dumped ECG signal in MATLAB

Chapter-6
Conclusions

At this stage the primary blocks of the design are complete. The prototype is only capable of

- Acquiring almost approximate ECG signal with very low noise margin.
- A portable and cost effective ECG acquisition device with integrated Bluetooth transmitter was developed.
- Digital Conversion and Wireless Transmission of any analog signal.
- Obtaining any data from the serial COM port of PC and importing them into MATLAB® and other application

Considering all the challenges in remote healthcare, we have planned to add features of basic health care examination such as heart rate, ECG analysis, stress meter and. Further the regenerated signal can be further analyzed for the different diagnostic purpose. At every stage we have tried to keep the cost as low as possible using commonly available ICs and universally used with Bluetooth.

Further, we have planned to make it compatible with android devices, which are readily and widely used now a day. After further modifications in the circuit and addition of sensors to measure heart rate, body temperature and blood pressure, etc. it'll be one the most compact and low cost device in healthcare sector.

Chapter-7
Summary

- In this device only the acquisition and recreation of ECG signal is being achieved. Further addition of sensors and circuits for the detection of heart rate, blood pressure, body temperature has to be done.
- The present device only records and display the ECG signal on an application in PC or Mobile. Further the software has to be optimized with the inclusion of facility to run diagnostic analysis on the received data. So that the requirement of a personnel for ECG data analysis can be eliminated.
- Implementation of BAN (Body Area Network) to test its flexibility with the obtained data and to determine the extent of its application.

Chapter-8
References

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